Coastal Engineering Technical Note

CORE-LOC CONCRETE ARMOR UNIT DESIGN

PURPOSE: This Technical Note provides initial stability and volume estimation design guidance for the CORE-LOC concrete armor unit.

INTRODUCTION: The CORE-LOC series of armor units, recently developed by the Corps of Engineers, provides optimized concrete armor units for protecting all coastal structures. The unit was designed to be placed in a single layer on either steep or shallow slopes. The unit shape was designed to have much lower stresses than existing slender armor units and to produce an armor layer with very little or no rocking units during design conditions. The unit was designed to also be used as a repair unit for dolos slopes because the dolos shape is overly slender producing high stresses in the interior of the unit. Also, the impact stresses due to rocking have been found to be very high in dolos armor units and dolos layers typically have between 1 percent to 2 percent of the on-slope units rocking, even for small wave conditions.

STABLE WEIGHT ESTIMATION: As discussed in the Shore Protection Manual, concrete armor unit design weights can be preliminarily estimated using the Hudson stability equation. For preliminary design, recommended maximum Hudson stability coefficients, K_D, for the CORE-LOC armor unit for all structures, assuming all transitions are sufficiently buttressed, should be 16. The use of larger values must be supported by comprehensive physical model studies.

The above guidance is very conservative relative to recent 2-dimensional physical model study stability results, where Hudson stability coefficients ranged up to 200 to 400 with no measureable damage. There are several reasons for using these conservative stability coefficients and they are:

1. The units have only been tested under idealized 2-dimensional wave conditions. No tests have been done under 3-dimensional directional wave conditions. Also, lateral, toe, and crown transitions have not been tested for stability. Transitions can be between stone and concrete armor, different shaped concrete armor, or different sizes of concrete armor, all of which have proven to be less stable than the interior of the armor layer matrix. The CORE-LOC units have also not been tested under combined wave-current situations. In addition, prototype armor placement may not always match model placement and irregular density placement or non-uniform interlocking conditions, as occurs during armor layer nesting, have not been examined in the physical model. Finally, the units have not been tested for a range of underlayer sizes and shapes, and this can affect the armor stability.

2. The stability of noninterlocked concrete armor units is far less than the stability of interlocked units; and on any rubble structure, there is always a risk that some units will become disentangled as the armor layer nests. As units become disentangled, the interlocking within the armor layer can decrease to the point where the armor layer will fail. The risk of this happening is far greater if the individual units are under-sized based on stability. Based on recent physical model tests of

the unit, the CORE-LOC appears to be far less susceptible to this unraveling phenomenon than other slender units because of its extraordinary interlocking. This is true even though it is constructed in a single layer. But, until the unit has been thoroughly tested, the unit should never be sized such that there is minimal non-interlocked stability.

3. Although the unit shape was designed such that interior stresses would be minimized, the CORE-LOC structural response has not been measured. Also, stability of broken units has not been examined nor has unraveling due to excessive breakage.

4. Using the recommended stability coefficients will still result in a very economical armor layer because the single layer produces armor layers requiring approximately 60 percent of the materials and units required for typical two-layer armor layers, such as that required for the dolos unit. Also, maintenance requirements of CORE-LOC armor layers should be less than other armor shapes because the unit size will be conservative.

The recommended coefficients are for preliminary design only and the design armor unit should be fully tested using 3-dimensional hydraulic physical model studies. Higher values of the stability coefficient may be used if supported by comprehensive 3-dimensional multi-directional-wave physical modeling; but even in these conditions, transitions and reduced interlocking due to armor layer nesting must be directly addressed. Although all site specific applications should be physically modelled, the recommended values of the stability coefficient may, in the future, be raised based on results from general parametric 3-dimensional testing.

For repair of existing dolos slopes, the CORE-LOC unit should be sized such that the CORE-LOC units will interlock with the existing dolosse. For units of the same weight, the CORE-LOC fluke length is only slightly shorter than a dolos fluke. Therefore, the repair CORE-LOC weight should be approximately the same as the existing dolos weight.

VOLUME ESTIMATION: Other information useful in the design of the CORE-LOC is summarized in the following table. The values for porosity, layer coefficient, and packing density are all rough estimates and will be refined in the future. Dolos design information is provided for comparison.

Table 1
Engineering Characteristics of CORE-LOC Unit per 1984 Shore Protection Manual

Unit	Volume, C is fluke length	Typical Number of Layers	Porosity**	Layer Coefficient	Packing Density	Typical Slope	Number of Units
	V	n	P as %	k_Δ	ϕ	cotα	N_s/C^2
CORE-LOC	$0.2403C^3$	1	$\approx 66^*$	$\approx 1.6^*$	0.54^*	1.5	1.40^*
Dolos	$0.1561C^3$	2	56	0.94	0.83	2.0	2.86

* These values are preliminary and will likely change as more thorough analyses are done.
** This is the porosity as computed using Equation 7-122 of the 1984 Shore Protection Manual

ADDITIONAL INFORMATION: Contact Mr. Jeffrey A. Melby ((601) 634-2062) or Mr. George F. Turk ((601) 634-2332). For Corps applications, design drawings of specific sizes of the CORE-LOC unit can be obtained.